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society

2012-2013
AGS BULLETIN
Vol. 9

Photograph of the Eagle Ford Fm. of West Texas.

Cover photograph: Photograph of Mr. Emory Hughes (age 16) straddling the Colorado River in Austin Texas ca. 1917. Mr. Hughes is wearing his St. Edwards ROTC uniform. The photograph was taken by Mr. Schneider about where Enfield Road meets the river. Photography courtesy of the Schneider Family and the Austin History Center.

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About the AGS Bulletin

AGS Bulletin Mission

(1) summarize the previous year's activities of the Society; and (2) publish technical papers, comments, and notes concerning the earth sciences of Central Texas.

Editors

Brian B. Hunt—Barton Springs Conservation District
John Mikels—GEOS Consulting
Dennis Trombatore—University of Texas at Austin

Publication and Copyright Information

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About the Technical Content

Presentation

The Austin Geological Society hosts technical presentations from invited speakers concerning the natural sciences. We publish an abstract in the Society's newsletter and allow for an abstract or extended abstract in the Bulletin.

Posters

The Austin Geological Society hosts a poster session each spring. Presenters can submit an abstract concerning their poster topic. Local middle and high school students, whose earth science projects were recognized by AGS at the Austin Regional Science Festival, are invited to present their projects at the AGS poster session. Student abstracts are published herein.

Field trip

The Austin Geological Society tries to have at least one field trip per year. The summary included here provides an overview of this year's trip. Interested readers are encouraged to purchase the guide book for additional information and details.

Technical Paper

The Bulletin accepts technical papers for publication provided that the papers pertain to local or regional geologic interests. Papers must meet technical and editorial requirements described in detail on the website.

Note

The Bulletin also accepts abbreviated narratives, figures, and notes; which may be technical, historical or anecdotal in nature.

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CONTENTS

2012-13 PRESIDENT'S PRATTLE

Dr. Peter R. Rose, Austin Geological Society President 2012-2013.

The Editors of the AGS Bulletin couldn't wrangle Pete to get his parting words before this went to Press. However, we think we can sum up much of what Pete would say as a parting thought to the AGS membership. He would do it in one word--Onward! As you will see from this edition of the Bulletin, it has been a year of action—and a very good year for the Society. We have Pete and the numerous Officers and Chairs of the Austin Geological Society to thank for that.

Austin Geological Society Officers 2012-2013

President—Pete Rose
President-Elect—Dennis Trombatore
Vice-President—Mustafa Saribudak
Secretary—Scott Tiller
Treasurer—Jim Sansom
Past President—Johnathan R. Bumgarner

Committee Chairs

Finance—Dallas Dunlap
Field Trip—Chock Woodruff
Newsletter Editor—Dan Neal
Membership—Scott Tiller
Publications—Steve Ruppel
Student Liaison (Graduate) —Vacant
Student Liaison (Undergraduate) —Vacant
Endowed Scholarship—Shane Valentine
Education—John K. Mikels
Awards—Pete Rose
Historical—Dennis Trombatore
AGS Bulletin—Brian Hunt
AAPG—Laura Zahm

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AGS NEWS

Membership

Austin Geological Society has 163 paid-up members as of April 1, 2013.

AGS Financials

AGS is working to receive non-profit 5013(c)(3) status. Austin Geological Society is solvent, with working capital of about $4,000, and savings of about $10,000. Our annual income ($4,500) closely matches our annual outgo, and we are seeking ways to increase our annual income, as well as charitable donations. We look forward to receiving a nice check from GCAGS in recognition of our sponsorship of the successful Annual Meeting in October 2012.

"Inner Space Cavern: Its Discovery and the Study of its Environmental and Biological Archives"

April 3, 2013

Presentation by Jim Sansom, Dr. Ernest Lundelius, and Dr. Jay Banner at the Williamson County Court House. Jim spoke about its discovery. Jay spoke about cave development in the Edwards Formation in Central Texas and the research that he is continuing to do on the same. Ernie discussed the bones found in Inner Space Cave and other caves in the Central Texas area. Ernie is a vertebrate paleontologist retired from UT faculty after 40 years of teaching. Jay is currently on UT Jackson School faculty. Jim is an independent consulting geologist.

AGS Education and Outreach Activities

Thanks to the AGS members who volunteered their time and talents in these Education/Outreach activities!

- Science Night at Murchison ES (Pflugerville ISD)
- Bridge Point Elementary School (Eanes ISD), presented "Rock Your World: everyday use of rocks & minerals"
- Geology and soils Fieldtrip to Wild Basin Preserve: Capitol Area Master Naturalist Class
- Earthscience Week Career Fest in October, for Austin-area Middle-school students
- Regional ScienceFest at the Palmer Events Center. AGS members judged Jr & Sr Earth & Environmental Science categories.
- Geology talk given to the Taylor Middle School Career Fair.

AAPG Award to AGS Member Alex Broun

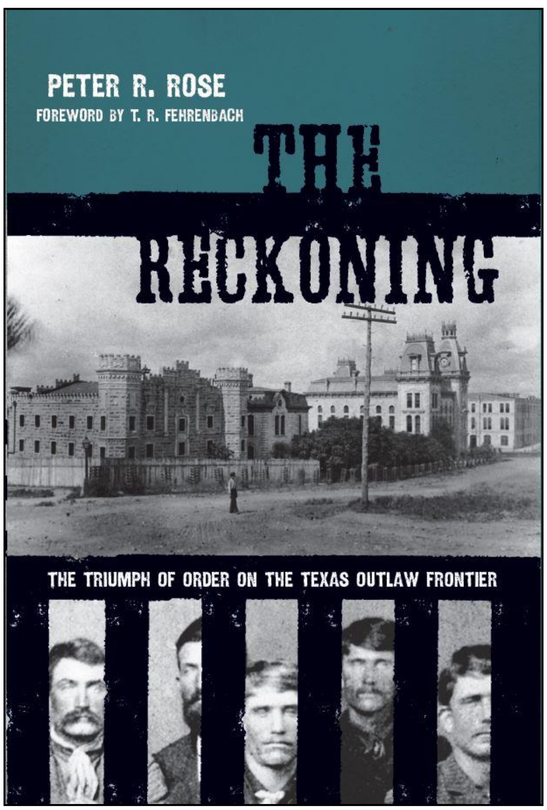
May 19, 2013

AGS member Alex S. Broun received the Public Service Award of the American Association of Petroleum Geologists (AAPG) at its annual meeting in Pittsburgh on May 19, 2013. This award recognizes the superb geological work and report that Alex, together with lead co-authors Doug Wierman and Brian Hunt, carried out concerning the Trinity Aquifer in the eastern Hill Country of Texas, in cooperation with volunteers and scientists from Blanco, Hays and Travis Counties, Texas. Not only was this a substantial contribution to good future water management in a water-short area, but the quality of the report itself is simply stunning. Congratulations Alex! Congratulations, Doug and Brian!

AGS congratulates President Pete Rose on the recent publication of his new book*:*

The Reckoning: The Triumph of Order on the Texas Outlaw Frontier

September 2012



Lubbock, Texas Tech University Press, 248 pp. (http://ttupress.org/books/the-reckoning-cloth)

Baylor University Visit

February 9, 2013

AGS members made a visit to Waco on Saturday February 9, 2013. Nine people took two vehicles to visit the Baylor Geology Department, courtesy of Dr. Steve Dworkin, and then to the Mammoth Site for a tour, followed by a stimulating lunch at Portofino's. Baylor's new geoscience facility is nicely integrated, and their emphasis has changed and is growing, especially in the stable isotope area. The group considered the experiment a success, and more such visits may be organized in the future, which we hope will lead to new possibilities with regional colleagues.

AGS Scholarship Awardees

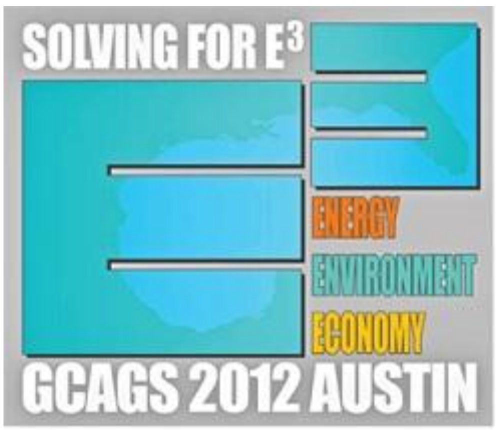
April 18, 2013

At the JSG Annual Student Awards ceremony Dr. Rose presented the annual $500 scholarships to two JSG upperclassmen, Aaron Hantsche, and Nicole Kurka. The funds will be used to defray essential costs associated with their summer field camp. AGS has offered such scholarships for many years, and it is satisfying to see the good we are doing, in helping students today, just as our elders helped us when we were struggling students.

Note: The Austin Geological Society established an endowed scholarship fund in 1992. The fund currently has about $28,000 in total.

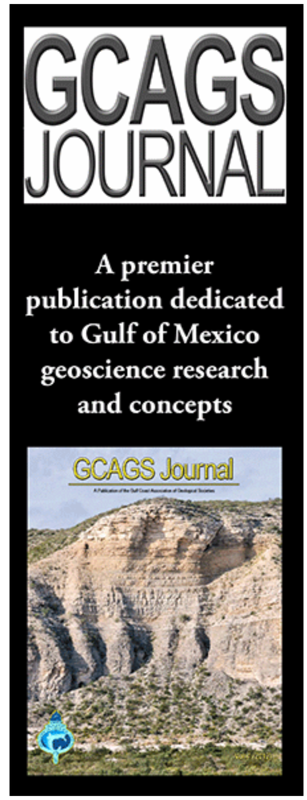
GULF COAST ASSOCIATION OF GEOLOGICAL SOCIETIES

Annual Convention, Austin Texas
October 21-24, 2012



The 62nd Gulf Coast Association of Geological Societies Annual Meeting and Convention was hosted by the Austin Geological Society in October 2012 at the Austin Convention Center.

AGS is not a newbie to running these large regional conferences--the 52nd Annual Meeting was last here in 2002. By all accounts, this year's meeting was just as successful as the last. The meeting was exciting and impactful--with over 170 talks, keynotes, and posters presented on Gulf Coast Geology with numerous contributions by AGS members reflecting the enthusiasm of both AGS and the local geoscience community. Like all big meetings, conventions are judged by two criteria; (1) does the technical program reflect the great science coming from the Gulf Coast region, and (2) is the meeting a financial success for both AGS and GCAGS. By both these measures, we met and exceeded our best expectations.



The 2012 GCAGS had one of the largest technical programs in the last several years with over 170 oral and poster presentations. While large, it was also scientifically diverse, with packed sessions on water resources and sustainability, shale exploration, and deepwater GOM plays. This rich diversity of talks was indicative of the conference theme: E3 = where Energy, Environment, and Economy intersect. GCAGS President and AGS Past-President Scott Tinker and Technical Program Chair and AGS members Lesli Wood and Kitty Milliken, conceived the theme and organized a superior program with leading session chairs and presenters over the four-day period. The Technical program was further bolstered by the inclusion of "the best of Veracruz" session consisting of nearly 15 oral presentations and 20 poster presentations originally scheduled for the 2011 Veracruz GCAGS meeting.

Dr. Scott Tinker (UT-BEG), GCAGS President of the 2012 GCAGS Conference (and former AGS President), gives opening remarks.

A broad range of universities, exploration and service companies, and geoscientific software companies were present in the Exhibit Hall. In the end, there were 95 booth spaces sold, a large number for a regional conference, with many companies securing 2, 3, or even 4 booth spaces. With this backdrop, the organizing committee held the opening Icebreaker and on Monday night, a fabulous President's reception hosted by Scott Tinker and GCSSEPM President and AGS member Ursula Hammes on the exhibit floor. The exhibitor sales effort was driven by JSG project manger Patty Ganey-Curry with great success. Sponsorship also set records, lead by AGS member Laura Zahm. The committee raised $236,000 in overall contributions. Without these sponsors the conference would not have been possible. They included local sponsors such as the Barton Springs/Edwards Aquifer Conservation District and the JSG to global exploration companies like Shell, ConocoPhilips, BP, and StatOil.

Most importantly to the financial success of the meeting were the attendees: professionals, spouses, exhibitors, and students who attended and made the meeting what AGS hoped it would be. By the Tuesday morning we passed our goal and ended the meeting with 1,125 total attendees. Many of those registrants further attended Short Courses, Field trips, and Luncheons. AGS Past-president Brian Hunt and AGS Committee Chair Stephen Ruppel ran field trips and short courses, respectively. With all contributions from sponsors, exhibitors, and attendees, the conference grossed $88,000 in profits and nearly $31,000 of that given to the AGS. These proceeds will go to form an endowed fund for AGS philanthropy to support varies activities that AGS deems worthy.

The success of this meeting would not have been possible without the support and service of AGS. The executive board was a constant source of talent and suggestive advice and a true partner in this undertaking. Other AGS members that acted as committee chairs of the organizing committee included Allan Standen (Treasurer), Angela Ludolph (Secretary), Kitty Milliken (GCSSEPM technical Program), Tucker Hentz (Editor), Gregory Frieborg (Judging), Vishal Maharaj (Registration), Sigrid Clift (Spouse), Mark Rainer (Entertainment), and Past-President Shane Valentine (AV). Many other AGS members acted as volunteers at the meeting or on various committees. Most importantly were the contributions of AGS Past-President Doug Ratcliff as Vice Chairman. His leadership and immense knowledge of GCAGS were a constant asset utilized extensively by the General Chair and President throughout the planning process.

The AGS will be called on again in 2021 to launch the 71st GCAGS Annual Meeting and Convention and we hope that AGS will be excited to produce a meeting even better and stronger than this one. We look forward to seeing everyone back again!

--Dallas Dunlap, GCAGS General Chair

AGS and GCAGS Field Trips

A total of 5 field trips were conducted (4 pre-meeting and 1 post-meeting) for a total of 89 registrants. One of the field trips was a free tour of the Vertebrate Paleontology Lab (VPL) and Nonvertebrate Paleontology labs (NPL) at UT Austin's Pickle Research Center. All other field trips had transportation (buses), lunch, drinks, and guidebooks provided and cost between $90-$400 per person. Four UT-Austin students were sponsored to attend three different field trips.

Eagle Ford field trip participants at Judge Roy Bean's court in Langtry.

2012 GCAGS/AGS Field Trips

Title	Date	Primary Leader	Attendees
Geology and Geomorphology of Enchanted Rock State Natural Area	Oct 21	Robert Reed	9
Geology, Frontier History and Selected Wineries of the Hill Country Appellation, Central Texas	Oct 24	Pete Rose	19
Eagle Ford Unconventional Mudstone Reservoirs Field Seminar: West Texas	Oct 20-21	Arthur D. Donovan	29
Volcanic Features of Austin, Texas	Oct 21	Chris Caran	20
Tour of the Vertebrate and Non-vertebrate Labs, Pickle Research Center, Austin, Texas	Oct 21	Ann Molineux	12

Photo from a field trip titled "Eagle Ford Unconventional Mudstone Reservoirs Field Seminar: West Texas" led by Art Donovan.

Photo from a field trip titled "Eagle Ford Unconventional Mudstone Reservoirs Field Seminar: West Texas" led by Art Donovan.

SOUTH-CENTRAL SECTION GEOLOGICAL SOCIETY OF AMERICA

The South-Central GSA meeting was held in Austin and attracted more than 684 attendees and a successful scientific program of 335 abstracts. AGS helped sponsor the meeting and had its logo displayed prominently on the website. AGS members played an active role in various committees and presenting abstracts.

AGS and GSA Field Trips

Nearly 100 people attended seven diverse field trips offered as part of the conference--AGS members played a key role in several of the trips. The table below lists the trips. Several of the trips were published in the GSA Guidebook 30.

Marcus Gary organized a special session of Karst Hydrogeology for the GSA meeting that included presentations in Natural Bridge Caverns. Brian Hunt shown talking to a group that included many AGS members. Photo courtesy of UT Austin.

2013 SC-GSA/AGS Field Trips

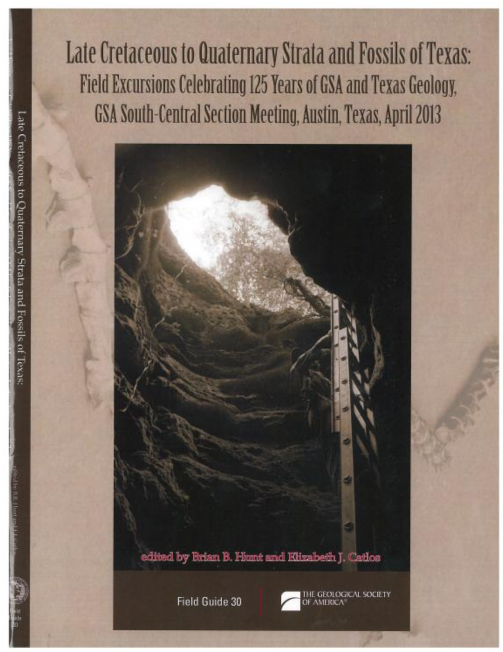
Title	Primary Leader	attendees
Urban Hydrogeology of Austin, Texas	C.M. Woodruff, Jr., Edward W. Collins, and Raymond M. Slade, Jr.	23
The Llano Uplift, central Texas: Field Trip for Teachers and Geologists at Any Level	Leon Long, Laurie Schuur Duncan, Hilary Olson, and Rich Ketcham	19
Late Cretaceous Strata and Vertebrate Fossils of North Texas	Louis L. Jacobs, Michael J. Polcyn, John Wagner, and Dale Winkler	11
Friesenhahn Cave: Late Pleistocene Paleoecology and the Predator-Prey Relationships of Mammoths with the Extinct Scimitar Cat	Russell W. Graham; Ernest L. Lundelius, Jr.; Larry Meissner	18
Late Cretaceous (Campanian) Submarine Volcanism and Associated Carbonate Deposition, Austin Area, Central Texas	S. Christopher Caran; Alan J. Cherepon	13
Geology and Geomorphology of the Enchanted Rock State Natural Area, Central Texas	Rob Reed	10
Traverse of Tertiary Sedimentary Rocks (Paleocene-Miocene), Central Texas Gulf Coastal Plain	Earle F. McBride and Charles M. Woodruff	4

Tertiary field trip participants at the unconformity between the high Quaternary gravels above the Carrizo Sand at Red Bluff southeast of Bastrop.

Tertiary field trip participants at Acme Brick pit (Calvert Bluff Fm.).

Raymond Slade speaking at Redbud Isle during the Urban Hydrogeology of Austin field trip.

Dr. Jack Sharp standing in front of Johnson Swallet on the Blanco River during the GSA Hydrodays Field Trip.



A Field Trip Guidebook was published titled: Late Cretaceous to Quaternary Strata and Fossils of Texas: Field Excursions Celebrating 125 Years of GSA and Texas Geology, GSA South-Central Section Meeting, Austin, Texas, April 2013; Editors: Brian B. Hunt and Elizabeth J. Catlos

Volcanics Field Trip Overview

By Al Cherepon and Chris Caran

Austin Geological Society members Chris Caran, Alan Cherepon, and other contributors, led field trips for two conferences in 2012-2013. The field trips were for the Geological Society of America South Central Section (GSA SCS) Meeting in April 2013, and the Gulf Coast Association of Geological Societies (GCAGS) 62nd Annual Convention in October 2012, both held in Austin. Both field trips were slight revisions of the AGS in the Spring 2006 Fieldtrip (AGS-26, Volcanic Features of Austin, Texas). The GSA field trip had greater revisions and a title revision as well; Late Cretaceous (Campanian) Submarine Volcanism and Associated Carbonate Deposition, Austin Area, Central Texas. This revision includes new summary information on recent work related to newly discovered fossil assemblage in the McKown Formation from the Dean Word Quarry near McKinney Falls State Park. The Fieldtrip stops include exposures of Late Cretaceous igneous extrusions, sedimentary deposits and carbonate accumulations associated with submarine tuff mounds. These exposures also reveal features found in oil and gas fields developed in 'Serpentine Plugs,' which are buried tuff mounds and their associated carbonates. Highlights of the trips included a more intensive look at the McKown Formation near McKinney Falls, a visit to Pilot Knob, exposures of volcanic materials and features (such as the first lava tube and pillow lavas discovered in the Austin area), and the impressive volcaniclastic exposure along Onion Creek.

Volcaniclastic exposure along Onion Creek.

Volcaniclastic exposure seen on the field trip.

ABSTRACTS OF PRESENTATIONS

The Ajax Dilemma

Paul B. Woodruff, PhD
August 27, 2012
Bureau of Economic Geology

Different teammates make different kinds of contributions to the success of the team. How do you decide who gets the big rewards? And where does justice lie between the loyal hard worker and the brilliant idea person? Do we pay for work done or to preempt outside offers? These are the questions I consider in my book, "The Ajax Dilemma: justice, fairness and rewards", 2011, Oxford University Press

Biography
1965 A.B. in Classics, Princeton University,
1968 B.A. in Literae Humaniores, Oxford University (Merton College), 1973 Ph.D. in Philosophy, Princeton University Professor of Philosophy and Classics, Dean of Undergraduate Studies, The University of Texas at Austin. Well-known for his influential articles on Socrates and Plato, Professor Woodruff has also published critical editions of Plato's Hippias Major (1982), Ion (1983), and (with Alexander Nehamas) Symposium (1989) and Phaedrus (1995). He has also written on topics in aesthetics and ethics. His recent publications include Reverence: Renewing a Forgotten Virtue(Oxford University Press, 2001), Socrates on Reason and Religion (edited with Nicholas Smith, Oxford, 2000), Early Greek Political Thought from Homer to the Sophists (Cambridge, 1995, with M. Gagarin), Thucydides on Justice, Power, and Human Nature (Hackett, 1993), and contributions to Essays on the Philosophy of Socrates (Oxford, 1994), Essays on Aristotle's Poetics (Princeton, 1992), and The Cambridge Companion to Early Greek Philosophy (1999). He has been Visiting Professor at the University of Pittsburgh and has twice directed NEH seminars on ancient philosophy.


Pete Rose (L) and Paul Woodruff (R) in discussion during the annual ethics talk.

Sedimentology Research in the High Arctic (Spitsbergen): Impact on Sequence Stratigraphy Models

Ronald J. Steel, PhD
October 1, 2012
Jackson Geology Building, Boyd Auditorium

Jackson School research on Spitsbergen since the early 2000s has highlighted a series of well-exposed outcrop transects from the West Spitsbergen Fold & Thrust Belt out across the deepwater Paleogene foreland basin. These outcrops are the only continuous ‘walk-out’ outcrops connecting coastal plain-shelf-deepwater slope and basin floor on the globe, and as such are important in looking at the controls on sediment-budget partitioning from shallow to deepwater areas during sea-level and supply ‘cycles’ in active tectonic basins. The Van

Keulenfjorden outcrops have the distinction of confirming and amplifying details of the various lowstand architectural elements of the Exxon sequence stratigraphic model from the 1980s, but ironically also paved the way for Jackson School students to document alternatives to the sea-level model for the growth of submarine fans in other areas. These latter models lay more weight on sediment supply and on dominant process regime at the shelf edge as the driver of fan development, and are especially important in addressing the tectonic and Greenhouse weaknesses of the earlier model. It should be added that Exxon researchers themselves have now dropped the earlier tight connection between facies tracts and the sea-level cycle.

Biography

B.Sc (Hons) in Geology, University of Glasgow; Ph.D. University of Glasgow, Scotland, 1971; Davis Centennial Chair and Professor, Department of Geological Sciences; Jackson School of Geosciences, The University of Texas at Austin Research focus – Clastic sedimentology, basin analysis, and dynamic stratigraphy; Former faculty at University of Wyoming; Former Chief Geologist for Norsk Hydro.

Switch

Fueling a tanker in Qatar, the world's largest producer of LNG.

Scott W. Tinker, Ph.D.

Film produced by ARCOS Films,

November 12, 2012

University of Texas at Austin Campus, Student Activity Center

Dr. Tinker explores the world's leading energy sites, from coal to solar, and oil to biofuels. He gets straight answers from the people driving energy today, international leaders of government, industry and academia. Switch is part of the Switch Energy Project, a multi-prong effort designed to build a balanced national understanding of energy.

Scott Tinker is Director of the Bureau of Economic Geology, the State Geologist of Texas, Director of the Advanced Energy Consortium, a Professor holding the Allday Endowed Chair and acting Associate Dean of Research in the Jackson School of Geosciences at the University of Texas at Austin. Scott spent 17 years in the oil and gas industry prior to coming to UT in 2000. Scott is past elected President of the American Association of Petroleum Geologists (AAPG), past president of the Association of American State Geologists, and current president of the Gulf Coast Association of Geological Societies. Tinker has been a Distinguished Lecturer for the AAPG and Society of Petroleum Engineers, a Distinguished Ethics Lecturer for the AAPG, and is the current GSA Halbouty Distinguished Lecturer. Tinker is a Fellow of the Geological Society of America, holds appointments on the National Petroleum Council, the Interstate Oil and Gas Compact Commission, the Geoscience Advisory Board at Sandia National Lab, Trinity University Board of Visitors, and several other private, professional, and academic advisory boards. Tinker was recently named a "Top Producer in Texas" by Texas Monthly magazine. Tinker's degrees are from the University of Colorado (Ph.D.), the University of Michigan (MS), and Trinity University (BS). Tinker's passion is building bridges between academia, industry and government and towards that end he has given nearly 500 invited and keynote lectures, visited nearly 50 countries, and most recently produced and is featured in the acclaimed documentary film on global energy, SWITCH.

Biography

B.S. Geology and Business Administration, Trinity University, San Antonio, Texas; M.S. Geological Sciences, University of Michigan, Ann Arbor, Michigan; Ph.D. Geological Sciences, University of Colorado, Boulder, Colorado; Professor, Edwin Allday Endowed Chair in Subsurface Geology, Department of Geological Sciences, Jackson
School of Geosciences, The University of Texas at Austin; Research and Technical Interests – Global energy supply and demand Technology administration Multidisciplinary reservoir characterization Carbonate sedimentology Sequence stratigraphy 3-D reservoir modeling Resource assessment.

Panel discussion: Impact of 2012 Texas Supreme Court Decision on Edwards Aquifer Authority vs Day & McDaniel on Texas Ground Water Use

Robert Mace, PhD (Moderator)
December 3, 2012
Bureau of Economic Geology

This was a lively discussion of the implications of future round-water management in Texas, by four very knowledgeable professionals, chaired by a ground-water scientist who is familiar with all aspects of the Texas ground-water scene. Robert Mace is the Deputy Executive Administrator for Water Science & Conservation at the Texas Water Development Board.

Russ Johnson (Attorney) -- 'What Day & McDaniel means from the private property rights perspective"
Brian Sledge (Attorney) -- "What Day & McDaniel means from a groundwater management perspective"

Kirk Holland (General Manager, Barton Springs/Edwards Aquifer Conservation Dist.) – "What Day & McDaniel means for Barton Springs"

Doug Hall (Geologist/Consultant) -- What Day & McDaniel means for private-sector business and practice"

Lone Star Silver Rides Again: the Reopening of the Shafter Silver Mine, Presidio County, Texas

J. Richard "Rich" Kyle, Ph.D.
February 4, 2013
Bureau of Economic Geology

The Shafter mine in Presidio County produced ~35 million troy ounces of silver (current value of more than $1 billion) from the 1880s until 1942 when multiple war-related issues resulted in its closure. An extensive drilling program in the early 1980's revealed that the downdip extension of the ore zone contained a significant resource, now estimated to be 24.6 million ounces of silver at an average grade of 8.5 ounces per ton. After a period of disinterest related to low silver prices, Rio Grande Mining Co. acquired the property, resulting in the reopening of the Shafter mine in June 2012. The company invested ~$50 million in the development of a 1,500 ton per day ore processing facility, providing jobs and otherwise stimulating the local economy.

The orebody consists of zinc-lead-silver replacements in karsted Permian carbonates just below the pre-Cretaceous unconformity within the Marfa Basin. The ore zone has been deeply oxidized, obscuring many of the original features. Although the deposit is located near several younger volcanic centers, current information suggests that mineralization was related to ~60 Ma Laramide magmatism, as represented by the Red Hills magmatic center that is exposed about 5 miles to the west of Shafter orebody.

In addition to covering the economic geology of the Shafter area, Professor Kyle will review the geologic and human history of this most interesting part of west Texas.

Biography
J. Richard Kyle, Yager Professor, Department of Geological Sciences and Bureau of Economic Geology, Jackson School of Geoscience, The University of Texas at Austin.
Ph.D., Geology, 1977, University of Western Ontario, London, Canada
M.S., Geology, 1973, University of Tennessee, Knoxville, Tennessee
B.S., Geology, 1970, Tennessee Technological University, Cookeville, Tennessee

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Experimental Stratigraphy and Geomorphology at UT-Austin

David Mohrig, Ph.D.
March 4, 2013
Bureau of Economic Geology

The growth of quantitative analysis and prediction in Earth-surface science has been accompanied by growth in experimental stratigraphy and geomorphology. The appeal of experiments in stratigraphy and geomorphology is not hard to understand. Experimental landscapes evolve under controlled conditions, so they allow study of steady states and response to changes in a single variable that would be difficult to observe in nature. In addition, a small, self-contained system can be studied and measured comprehensively to a degree that is rarely possible in the field. Finally, experiments greatly speed up time, allowing for many observations of what would otherwise be very infrequent events. I will discuss the types of experimental studies underway in the UT Morphodynamics Laboratory. This work includes understanding the production of deepwater stratigraphy, the response of coastlines to spatially varying subsidence patterns, the transport of gravel by flash floods, and the exchange of water between rivers and shallow groundwater aquifers. Following the presentation we will walk over to the lab for a tour of the experimental facilities.

Biography
David Mohrig, Professor, Department of Geological Sciences, Jackson School of Geoscience, The University of Texas at Austin. Ph.D. 1994 Geological Sciences, University of Washington, Seattle, Washington M.S. 1987 Geological Sciences, University of Washington, Seattle, Washington B.A. 1983 Geology, Pomona College, Claremont, California.

Texas Earthquakes, Natural and Manmade

Cliff Frohlich, Ph.D.
April 1, 2013
Bureau of Economic Geology

I will discuss my research concerning earthquakes and earthquake sequences that occurred in Texas within and near petroleum fields or injection disposal wells over the past two years. These include the M3.9 Alice TX earthquake of 25 April 2010, the 2008-2009 earthquakes near Dallas-Fort Worth, the 2009 earthquakes near Cleburne TX, the 20 October 2011 M4.8 earthquake southeast of San Antonio, and the 17 May 2012 M4.8 earthquake in east Texas near Timpson. It is no secret to those who remember the 1956 movie Giant, or the 1980's TV show, Dallas, that the oil and gas industry in Texas has been hugely active since the 1920's. What is less well known is that long before the current interest in induced seismicity, numerous earthquakes in Texas occurred within and near petroleum fields, and many of these may have been induced/triggered by human activity. I will briefly review these, and speculate about broader implications for scientist studying induced/triggered earthquakes today.

Biography

After Cliff Frohlich received his Ph.D. in Physics from Cornell University, for his first full-time job he signed a one-year contract as a Research Scientist with what is now the Institute for Geophysics at the University of Texas at Austin. Subsequently he has signed 35 one-year contracts with UTIG, where he is now Associate Director. He is the author of two books: Texas Earthquakes, co-authored with Scott Davis and published by UT Press in 2002, and Deep Earthquakes, published by Cambridge University Press in 2006. Since 2009 his research has focused primarily on earthquakes possibly triggered by activities associated with oil and gas production in Texas. Ph.D. 1976 Physics, Cornell University;
M.S. 1973 Physics, Cornell University; B.A. 1969 Mathematics, Physics, Grinnell College.

SCIENCE FAIR ABSTRACTS

AGS members volunteer as judges at the annual Regional Science Festival. The following abstracts were selected for recognition by AGS for their projects in the Earth and Planetary Science or Environmental Categories.

The Effects of Impervious Cover on Water Quality

Morgan Frisby, Bowie High School, Austin ISD

The purpose of this experiment was to determine if there is a relationship between water quality and the amount of impervious cover in an area. The experiment consisted of sampling three high impervious cover creeks and three low impervious cover creeks for freshwater mussel populations as an indication of the water quality. Dry Creek, a low impervious cover creek, had 34 mussels. It was the only one out of the six sites that had mussels; thus, there is no statistical difference between the amounts of mussels found in the high and low impervious cover creeks tested (p-value=0.42). One possible explanation for the lack of mussels is the effect of the recent drought. Due to the nonexistence of the mussel populations, the true impact of impervious cover on the water quality could not be determined.

Water Quality for Popular Types of Water

Ena Huskic, Vista Ridge High School, Leander ISD

By doing various tests on four types of water, my goal was to find which type of water would be the least contaminated, thus best for consumption. Four types of water samples were gathered ; tap filtered by BRITA, straight tap, Kirkland bottled water, and tap (boiled for 5 minutes on medium heat). All the samples were tested, with test strips, for bacteria, presence of lead and/or pesticides, nitrate/nitrite levels, pH, total hardness and total chlorine. It was found that the boiled water sample had the best results because, other than having a high pH (which can actually help boost a person’s metabolism, neutralize acid in the bloodstream and help prevent disease), the results were negative for all other tests including the presence of bacteria. The water that had the worst results was BRITA with bacteria present and a positive for nitrate/nitrite. To test for bacteria, samples of each type of water were smeared on petri dishes with nutrient agar for the bacteria to grow on and put in an incubator for four days. The water with the most bacteria on the petri dish was tap with a large colonization of bacteria about an inch long while the boiled water hadn't produced any. The BRITA and bottled water samples had an almost equal amount of bacterial growth (small specs). In conclusion, I found that the best, least contaminated water was the boiled tap because the heat had killed off the bacteria and, possibly, reduced the concentrations of other contaminants.

Polarimetric Radar vs. Dual Polarization Radar

Jonathan Wheeler, Vista Ridge HS, Leander ISD

The purpose of the project is to determine the accuracy between polarimetric (single-polarization) radar and dual-polarization radar. The procedure included collecting radar images from several (6) key weather events (in
this instance, tornadic events) from polarimetric radar. I then collected radar images from several (6) key weather events (in this instance, tornadic events) from dual-polarization radar. I collected storm reports for all events as well such as location, intensity, rainfall totals, watches and warnings issued at the times of the storms. I then compared the two different radars to determine which one collected more information. The data was confirmed, since there was a significant difference in accuracy between the radar types. I first looked at each image thoroughly to look for a hook echo. If a hook echo was detectable by the naked eye, I then looked to see and locate an approximate location of the tornado. The polarimetric radar had an approximate 83% chance of detecting a visible hook echo and collecting data via reflectivity. The dual-polarization radar had a near 100% chance at visibly detecting a hook echo and debris from tornadoes. There were some errors present, including a lack of radar images and a lack of detailed storm information. Knowing this, we could improve warning times, which, in turn, could potentially save many lives.

Technical Paper

Excursions of Mining Solution at the Kingsville Dome In-situ Leach Uranium Mine

by George Rice

Hydrologist, GRGwH

Abstract

In-situ leach (ISL) uranium mining differs from conventional mining in that it does not require excavation of ore. Instead, uranium is mobilized by injecting leaching fluids into a groundwater-saturated ore body. The uranium enriched groundwater (mining solution) is then brought to the surface through extraction wells. Approximately 1 to 3 percent more water is extracted from a uranium production well field than is injected. The purpose of this “bleed” is to prevent the escape of mining solution (excursions) by maintaining a hydraulic gradient toward the extraction wells.

The Kingsville Dome Mine is 13 km southeast of Kingsville, Texas. ISL mining began in 1988 and continued intermittently until 2009. The mine covers 864 ha and is divided into three production areas. This paper focuses on production area three (PA-3).

The bleed at PA-3 did not contain the increased pressures caused by injection of leaching fluids. A hydraulic gradient was rapidly established between the injection wells and the mine boundary, as shown by a rise in water levels in monitor wells surrounding PA-3. This gradient drove mining solution beyond the mine boundary. These excursions affected a well on the Garcia property, approximately 300 m down gradient of the mine. Since mining began, uranium concentrations in the Garcia well have increased from less than 200 µg/L, to more than 600 µg/L. This is the first time that contaminants in an off-site domestic well have been linked to ISL uranium mining in the United States of America.

In-situ leach uranium mining

In-situ leach (ISL) uranium mining differs from conventional mining in that it does not require excavation of ore. Instead, uranium is mobilized by injecting leaching fluids into a groundwater-saturated ore body (figure 1). The uranium-enriched groundwater (mining solution) is brought to the surface through extraction wells and routed to a processing plant where the uranium is removed. The uranium-depleted solution is then re-injected into the ore body. This cycle of injection and extraction continues as long as the ore body contains economically recoverable amounts of uranium.

Leaching fluids typically consist of water, oxidants (e.g., oxygen, hydrogen peroxide), and complexing agents (e.g., carbonates, sulfates) (NRC 2007). The oxidants convert uranium from the relatively insoluble U^{+4} state to the soluble U^{+6} state. The complexing agents combine with the oxidized uranium to form anionic or neutral complexes that remain in solution (e.g., $UO_2(CO_3)_3^{4-}$, $UO_2(SO_4)_3^{4-}$) (Charbeneau 1984). Uranium ore usually contains other toxic constituents such as radium, arsenic, molybdenum, and selenium (NRC 2007). These are also mobilized during ISL mining.

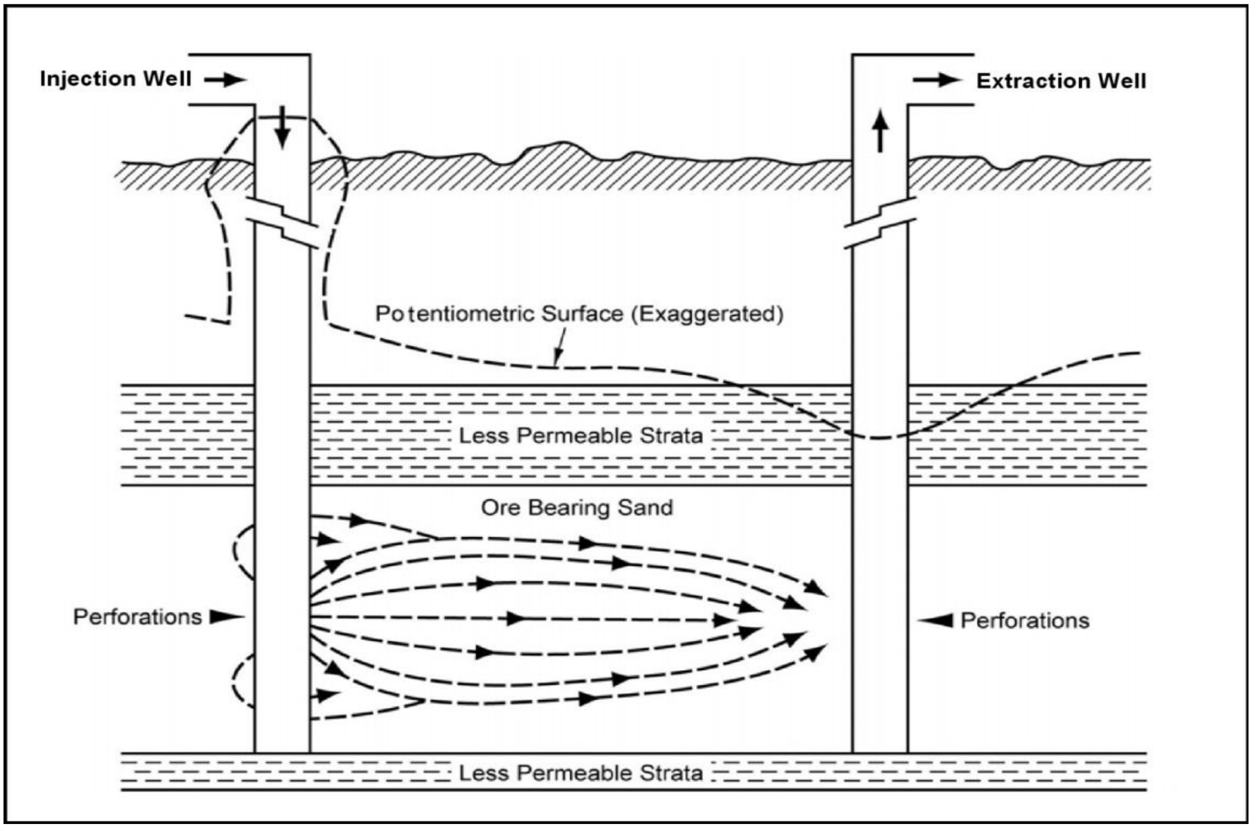

Figure 1. Schematic Cross Section, Injection and Extraction Wells (adapted from NRC 2009)

Most ISL mining occurs in fluvial sandstone aquifers (Staub et al. 1986). These fluvial systems are heterogeneous and anisotropic, consisting of interbedded clays, silts, sands, and gravels. They contain paleochannels that act as preferential flow paths, and overbank deposits that impede flow.

Injection and extraction wells are organized in patterns. Figure 2 shows a 5-spot pattern. Other patterns, e.g., 7-spot, are also used. A uranium production well field will usually contain a series of patterns arranged to follow the form of the uranium ore body. Well fields are grouped in production areas, and production areas are surrounded by a ring of monitor wells (NRC 2009).

Approximately 1 to 3 percent more water is extracted from a production area well field than is injected. The purpose of this “bleed” is to prevent the escape (excursion) of mining solution by maintaining a hydraulic gradient toward the extraction wells. An excursion is the flow of mining solution beyond the monitor well ring.

Figure 2 is an idealized depiction of groundwater flow. In practice, excursions are initiated when mining solution flows beyond the capture zones of extraction wells. This may be caused by failure to balance injection and extraction rates, failure to maintain sufficient bleed rates, or when mining solution is diverted by paleochannels.

After mining at a production area is completed, groundwater is supposed to be restored to its pre-mining quality (Texas Administrative Code, Title 30, §331.107). However, groundwater restoration after ISL mining is difficult. The United States Geological Survey reviewed 22 uranium production areas in Texas (USGS 2009). Toxic constituents (e.g., uranium, arsenic, selenium) had been restored to their pre-mining levels at only two of them. In no case had all constituents, including non-toxic constituents such as calcium and sulfate, been restored to their pre-mining levels (USGS 2009). Nonetheless, the Texas Commission on Environmental Quality (TCEQ) considers groundwater restoration to be complete at all 22 production areas (USGS 2009).

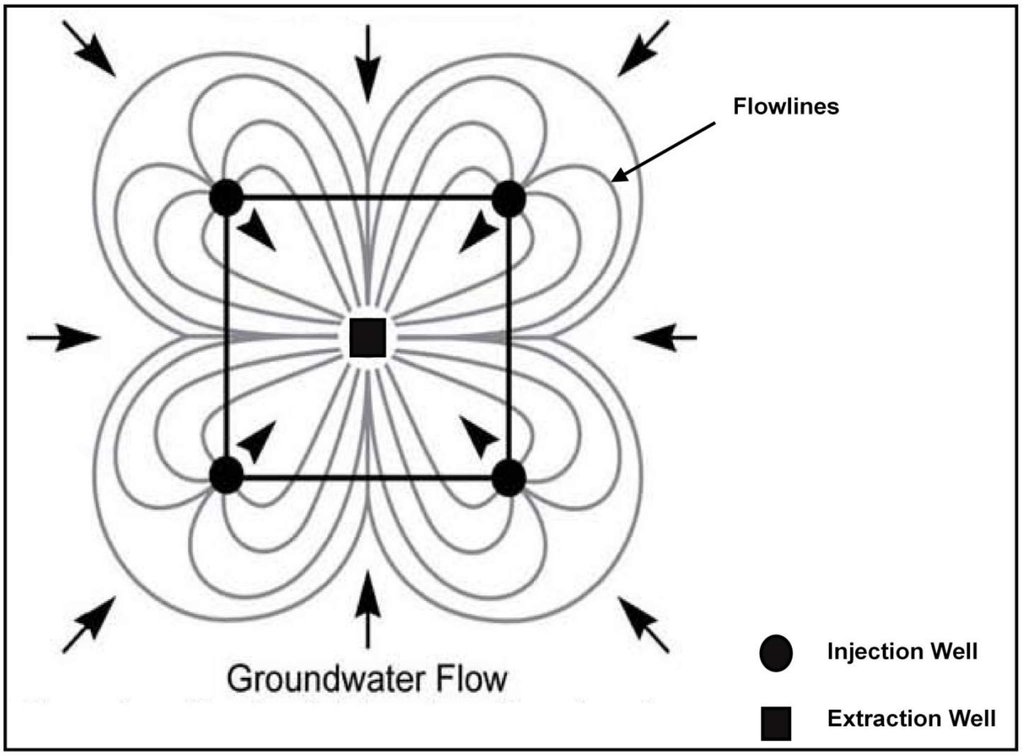

Figure 2. Schematic, 5-spot Injection-Extraction Well Pattern *(Adapted from NRC 2009)*

ISL mining at Kingsville Dome

The Kingsville Dome (KVD) mine is owned and operated by Uranium Resources Inc. (URI). The mine is in Kleberg County, Texas, approximately 13 km southeast of Kingsville (figure 3). ISL mining began in 1988 and continued intermittently until 2009. The area licensed for mining covers 864 ha (TBRC 1985) and is divided into three production areas (PAs) (figure 4). This paper focuses on PA-3. Unless otherwise noted, all of the site-specific data regarding the KVD mine was obtained from documents submitted by URI to the TCEQ or its predecessor agencies.

There are domestic wells near the mine. All of them are monitored for uranium and other constituents associated with ISL mining. Two of them, the Garcia wells, are directly down gradient of PA-3 (figure 4).

The ore occurs in the Goliad Aquifer, a fluvial deposit consisting of interbedded clay, silt, and sand (Rice 2006). The ore is found between about 150 m and 225 m below land surface. The principal uranium minerals are believed to be uraninite (UO_2) and coffinite ($U(SiO_4)(OH)_4$) (McKnight 2006).

The groundwater is confined (Rice 2006) and generally flows toward the northwest (TBRC 1985). The current flow direction is not the natural direction. Under natural conditions, groundwater flowed southeast, toward the coast. However, pumpage in the vicinity of Kingsville reversed the hydraulic gradient and groundwater now flows toward Kingsville (Rettman 1983). Local groundwater flow directions vary. Calculated flow rates range from about 0.3 m/yr to 100 m/yr (Rice 2006). This range reflects the heterogeneity of the fluvial deposits. It should be noted that these flow rates are for non-mining conditions. During mining, local flow rates may be much higher due to the steep gradients caused by the operation of injection and extraction wells.

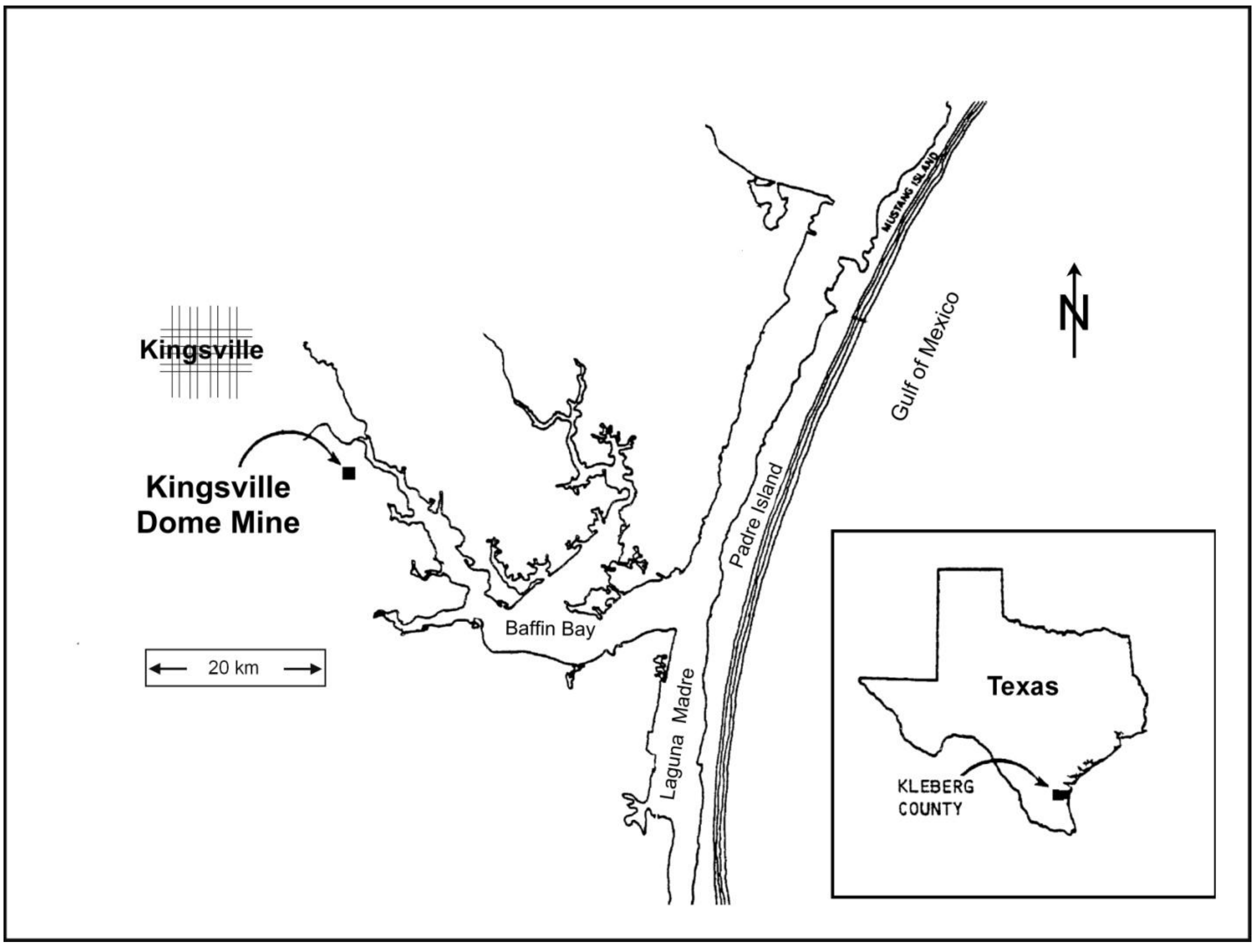

Figure 3. Mine Location Map

The leaching fluid used at the KVD mine is oxygenated water. Table 1 shows typical concentrations of constituents in the mining solution. URI uses a computerized model to adjust injection and extraction rates, but the model does not account for aquifer heterogeneities (Grant 2006). URI maintains a bleed of approximately one percent. The bleed is supposed to continue until groundwater restoration is completed, but URI has not always maintained the bleed as required (TCEQ 2003).

Table 1 Concentrations of Constituents in a Typical Mining Solution at the KVD Mine*

pH	Electrical cond.	Uranium	Chloride	Calcium	Bicarb-onate	Sulfate	Molyb-denum
(SU)	(µmhos/cm)	(µg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
6.6	4000	80,000	600	400	800	1200	10

**URI analysis of mining solution from extraction wells. It may be a mixture of mining solutions from many extraction wells. Data from Mark Pelizza of URI, 2005.*

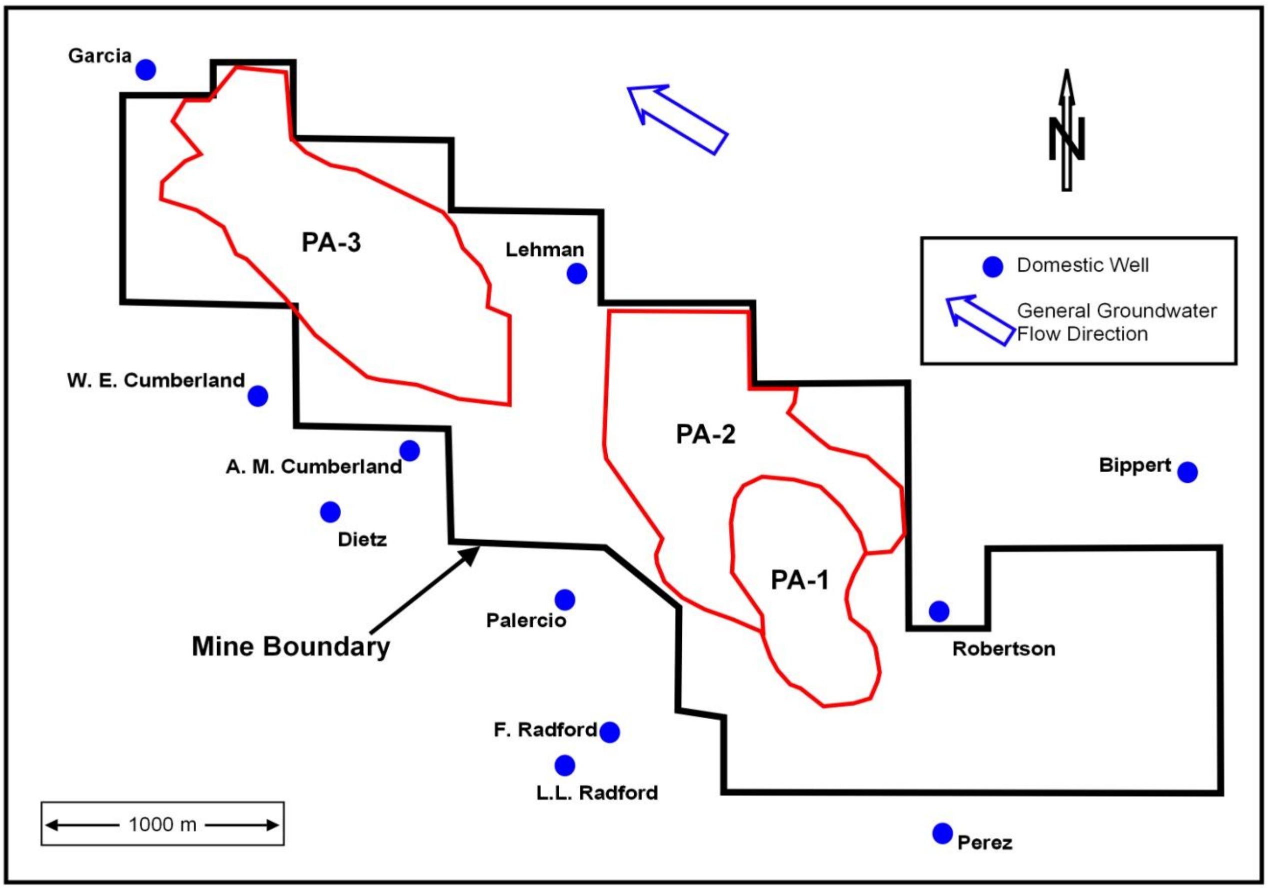

Figure 4. KVD Mine Map

The Effects of Mining on Hydraulic Gradients at PA-3

Excursions are driven by hydraulic gradients. During mining at PA-3, the hydraulic gradients driving excursions were the result of the injection of leaching fluids.

PA-3 covers 151 ha. Mining at PA-3 first began in June 1998 and was suspended in June 1999. During this first period, uranium was produced from well fields 9 and 10 (figure 5). Mining resumed in January 2007 and was suspended again in June 2009. During this second period, uranium was produced from well fields 13, 14, 15a, 16a, 16b, 17a and 17b. Well field 15b was installed but was not used to produce uranium (Van Horn 2012). Well field injection rates ranged from about 1400 L/min to 5000 L/min (TCEQ 2008; URI 1999). Complete well field injection data are not available. A request to URI for additional data was refused (URI 2012b).

PA-3 is surrounded by a ring of 49 monitor wells. Water levels have been measured in all the monitor wells, but the lengthiest records are from seven wells monitored under an agreement between URI and Kleberg County. Beginning in 2005, water levels were measured in wells MW-78, MW-83, MW-85, MW-89, MW-97, MW-102, and MW-125. Water levels in these wells were measured quarterly when mining was not taking place, and twice a month during mining. Water levels from these seven wells are used in the discussion below.

The injection of leaching fluids had a rapid effect on water levels in the monitor wells. The effect can be seen by comparing water levels before, during, and after mining. Water levels rose an average of 1.7 m in the year after the resumption of mining (table 2), and fell an average of 2.3 m in the year after the suspension of mining (table 3). Figure 6 shows water levels in two monitor wells for the one year periods immediately before and after mining resumed.

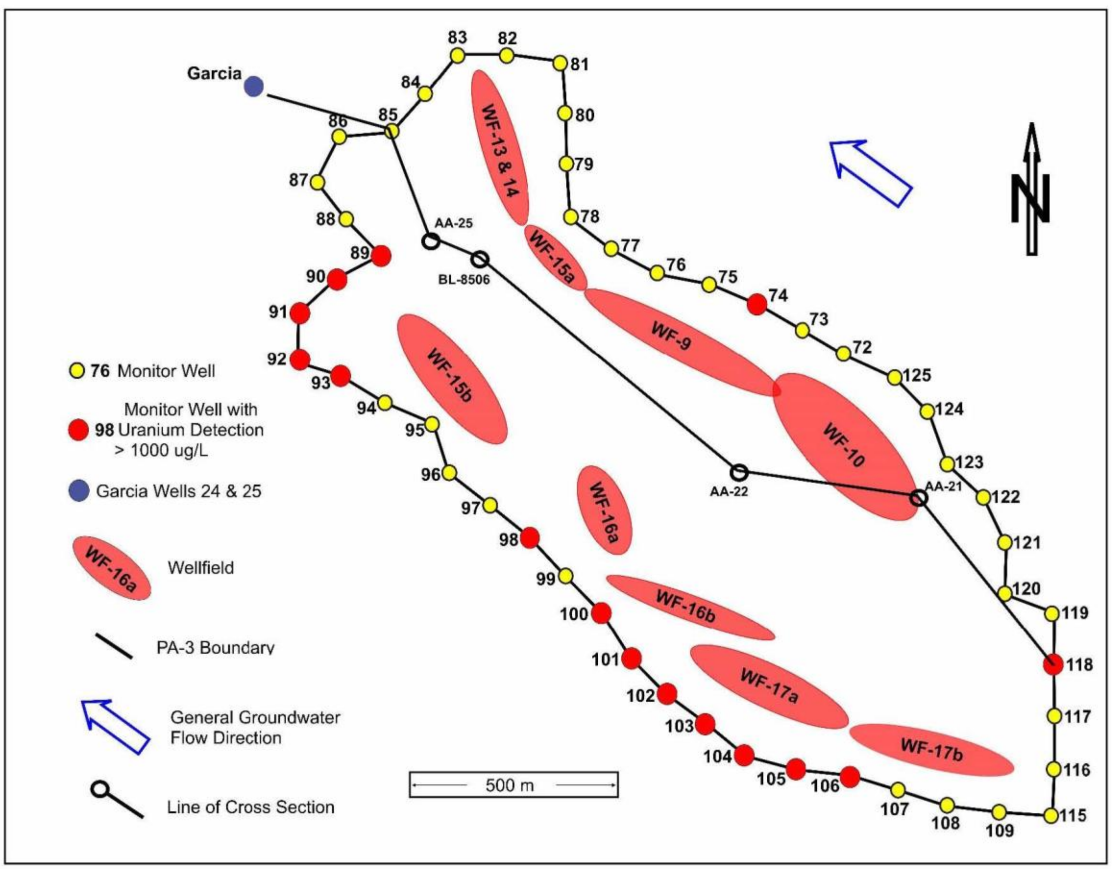

Figure 5. PA-3, Well Fields and Monitor Wells

Table 2 Water Level Rises in Response to Resumption of Mining*

Well ID	Average depth to water in the year before mining resumed (Dec 2005 – Dec 2006, m btoc**)	Average depth to water in the year after mining resumed (Jan 2007 – Dec 2007, m btoc)	Average rise in water level in year after mining resumed (m)
MW-78	36.21	34.53	1.68
MW-83	39.40	37.29	2.11
MW-85	40.45	37.77***	2.68
MW-89	37.69	36.67	1.02
MW-97	36.80	35.61	1.19
MW-102	37.28	35.84	1.44
MW-125	34.06	32.37	1.69
		Average of all wells:	1.67

** URI, 2012a. The average bleed rate during the year preceding mining was 62 L/min (URI 2007a, no pumping for restoration appears to have occurred during this period). The average bleed rate during the first three quarters of mining was 67.8 L/min (URI 2007b and 2008). There was no bleed during the remaining period of mining.*

*** btoc: below top of casing.*

**** With outlier removed. The outlier (56.48 m Aug 13, 2007) was approximately 18 m lower than any other measurement (URI 2012a). The average depth without removing the outlier was 38.58 m.*

Table 3 Water Level Declines in Response to Suspension of Mining*

Well ID	Average depth to water in the year before mining suspended (June 2008 – May 2009 m btoc)	Average depth to water in the year after mining suspended (June 2009 – May 2010 m btoc)	Average decline in water level in year after mining suspended (m)
MW-78	35.27	37.71	2.44
MW-83	37.47	40.27	2.80
MW-85	39.45	42.00	2.55
MW-89	37.08	39.46	2.38
MW-97	36.44	38.60	2.16
MW-102	36.90	38.79	1.89
MW-125	33.27	35.38	2.11
		Average of all wells:	2.33

** URI 2012a. The average pumping rate (bleed plus restoration) during the year following mining was 428 L/min (URI 2010).*

This rapid effect on water levels is to be expected. In a confined aquifer, changes in head are quickly propagated in response to the extraction or injection of water (Kruseman and De Ridder 1976). A similar response was seen during a pumped aquifer test at the KVD mine. In that test, water levels more than 1200 m from the pumped well began dropping less than ten hours after pumping began (TBRC 1985).

The rise in water levels shows that the bleed did not contain the increased pressures caused by injecting leaching fluids. The increased pressures were propagated beyond the monitor well ring, creating a gradient between the injection wells and monitor wells. Mining solution flowed down this gradient, toward the monitor wells. This resulted in excursions.

Excursions at PA-3

Excursions are monitored by measuring the concentrations of uranium and chloride, and the value of electrical conductivity (EC) at the monitor well ring. Monitor wells are sampled quarterly when mining is not taking place, and twice a month during mining.

Excursions at PA-3 are most readily identified by increases in uranium concentrations. This is because the concentration of uranium in the mining solution is more than 1000 times greater than the groundwater background concentration, while the concentration of chloride and the value of EC are only about two times greater than background (table 4).

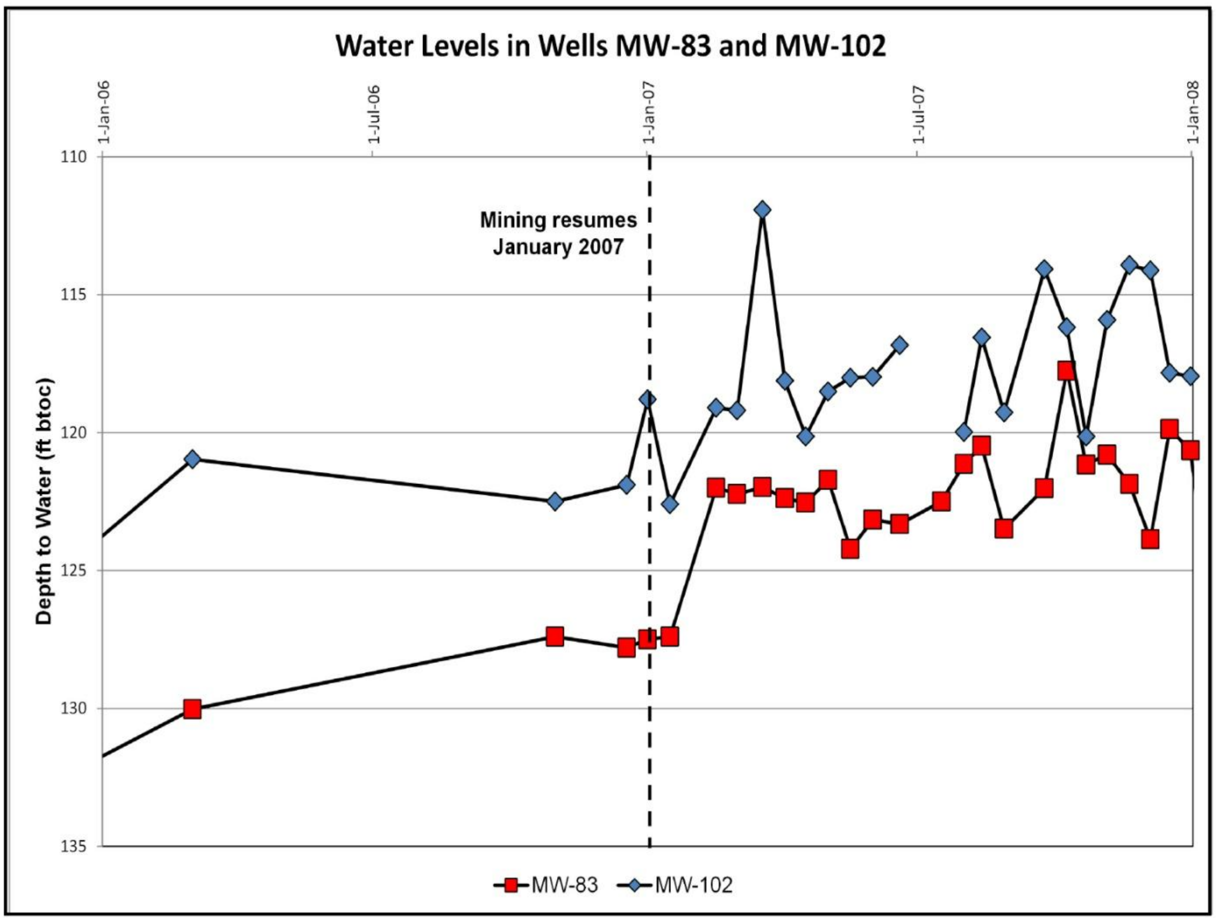

Figure 6. Response of Water Levels to Injection of Leaching Fluids

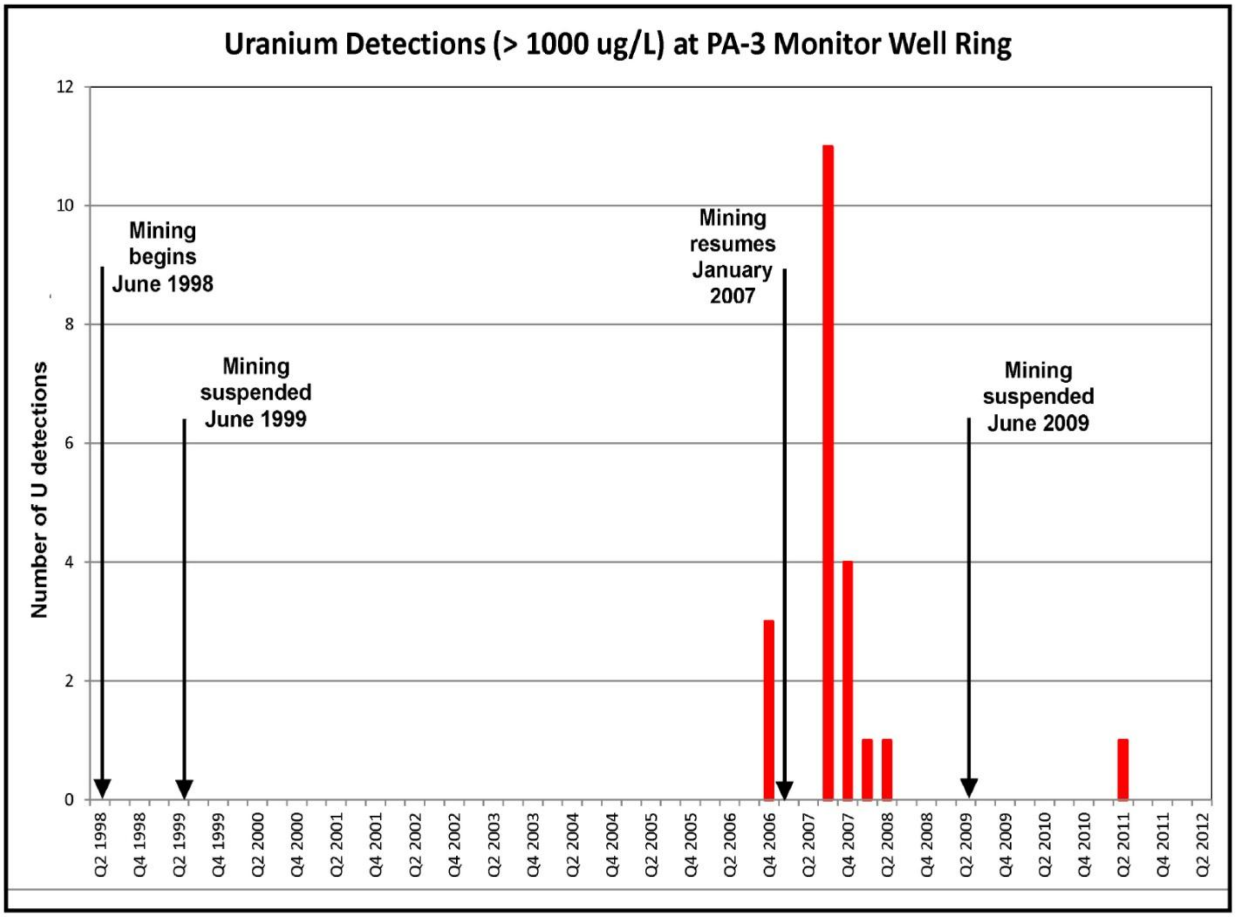

Figure 7. Timeline of Uranium Detections at PA-3

Table 4 . Uranium, Chloride, and EC Values In Mining Solution and Background Groundwater at PA-3

Parameter	Typical mining solution value	Range of background values*	Average background values*	Ratio of mining solution value to average background value	EPA drinking water standard**
Uranium (µg/L)	80,000	< 0.001 - 187	41	1950	30 µg/L
Chloride (mg/L)	600	214 - 443	282	2.1	250 mg/L
EC (µmhos/cm)	4000	1600 - 2590	2017	2.0	NA

** Pre-mining values in monitor well ring surrounding PA-3 (URI 1997).*

*** The uranium standard is a primary maximum contaminant level (MCL). MCLs are health-based and legally enforceable. The chloride standard is a non-enforceable secondary standard based on aesthetic effects (e.g., taste, odor) (EPA, 2009). NA: not applicable.*

Given the values in table 4, a mixture of 2% mining solution and 98% background groundwater would have the following values of uranium, chloride, and EC.

> Uranium: 0.02 (80,000 µg/L) + 0.98 (41 µg/L) = 1640 µg/L
> Chloride: 0.02 (600 mg/L) + 0.98 (282 mg/L) = 288 mg/L
> EC: 0.02 (4000 µmhos/cm) + 0.98 (2017 µmhos/cm) = 2057 µmhos/cm

Thus, a mixture of several percent mining solution with background groundwater could be readily identified by the increase in uranium concentrations, but the chloride and EC values would be difficult to distinguish from background values.

At least two factors act to reduce concentrations in the sampled mining solution. As the mining solution travels from the well field to the monitor well ring, hydrodynamic dispersion dilutes the concentrations of uranium and other constituents. There is also an apparent reduction in concentrations resulting from the design of the monitor wells. The well screens are 30 m long. Therefore, a plume of mining solution that is less than 30 m thick will be diluted by native groundwater when it is pumped from the well.

It should be noted that it is not necessary for uranium to travel from the well fields to the monitor well ring in order to increase uranium concentrations in the monitor wells. If uranium is present in the formation near the monitor wells, uranium concentrations can be increased by the arrival of oxidizing mining solution.

Apparent excursions of mining solution have been detected 21 times at PA-3 (table 5, and figures 5 and 7). More excursions have probably occurred, but URI does not report the values of uranium concentrations that are less than 1000 µg/L (see below).

Quality of analytical data and false positives

The uranium concentrations cited in this paper come from analyses performed by commercial laboratories and by URI's in-house laboratory. The background samples and samples from the Garcia wells were analyzed by commercial laboratories. All the monitor well samples, except the background samples, were analyzed by URI's laboratory.

There are two problems with the analyses produced by URI's laboratory. First, although TCEQ accepts the results, problems with their accuracy have been documented (Rice 2006). Second, when reporting uranium concentrations for monitor wells, URI reports only those values greater than 1000 µg/L. If a value does not meet this threshold, it is reported either as less than 1000 µg/L, or as zero. Zero is not an analytical result. It means that the concentration is below the detection limit. In this case, the detection limit appears to be about 20 µg/L (URI 2005). Thus, the uranium analyses reported by URI's laboratory fall into three groups: less than 20 µg/L, between 20 µg/L and 1000 µg/L, and greater than 1000 µg/L. The author has asked URI for the laboratory data showing uranium values below the 1000 µg/L threshold. URI refused (URI 2012b).

The problems with URI's uranium analyses raise the possibility that URI might have reported false negatives or false positives. In the absence of additional data, individual false negatives cannot be identified. But false positives may be identified by examining the circumstances associated with analytical results.

Table 5 **Monitor Wells with Elevated Uranium Concentrations**

Well ID	Background U concentration (µg/L)	U concentration during excursion (µg/L)	Date U detected
MW-74	21	3200	11/16/06
MW-89	22	1690	8/17/07
MW-90	24	1320	8/17/07
MW-90	24	1060	11/27/07
MW-91	31	2140	8/17/07
MW-91	31	1500	3/5/08
MW-92	36	1670	8/17/07
MW-92	36	1440	10/11/07
MW-92	36	1300	4/16/08
MW-93	37	2500	10/11/07
MW-98	59	1100	4/18/11
MW-100	30	3600	8/17/07
MW-101	53	2520	8/17/07
MW-102	20	1300	11/7/06
MW-102	20	5170	8/17/07
MW-103	16	2790	8/17/07
MW-104	36	2140	8/17/07
MW-105	31	2320	8/17/07
MW-106	32	3900	11/7/06
MW-106	32	1260	8/17/07
MW-118	101	1170	10/19/07

The uranium concentrations shown in table 5 would not be considered excursions by TCEQ. According to TCEQ, an excursion has not occurred unless uranium concentrations exceed 6540 µg/L (TCEQ 2006).

Figure 7 is a timeline showing the 21 uranium detections greater than 1000 µg/L. Four of the detections may be false positives because they are inconsistent with the history of mining at PA-3. Three of the four are from samples collected in November 2006, approximately two months before mining resumed. The fourth is from a sample collected in April 2011, almost two years after mining was suspended. There are other possible explanations for these four detections. The 2006 detections could be the result of pre-mining activities (e.g., testing of injection wells), or they could represent slow-moving, remnant solution from mining that occurred in 1998 and 1999. The 2011 detection could also be the result of slow-moving solution from earlier mining. At best, these four detections are suspect.

There are several reasons to believe that the other 17 uranium detections shown in figure 7 are not false positives. First, all of them occurred during mining. Second, all of them occurred after water levels in the monitor wells rose sharply in response to mining. This rise indicates that mining solution was being driven toward the monitor wells. Third, with one exception, the 17 detections are grouped in two clusters of wells: MW-89 – MW-93 and MW-100 – MW-106 (table 5 and figure 5). If the detections were false positives, one would expect them to be distributed randomly around the monitor well ring. In four of the wells, values greater than 1000 µg/L were detected more than once (table 5).

A suspicious feature of the detections shown in figure 7 is that 11 of them are from samples that were collected on one day, August 17, 2007. These detections could have been the result of problems in URI's laboratory. However, there are reasons to believe that this is not the case. First, a total of 27 samples were collected on August 17, 2007. Sixteen of the analytical results from that day were below 1000 µg/L. Second, all 11 detections occurred in the two well clusters mentioned above. Third, the 11 detections are not temporally isolated. That is, they are not anomalies that were preceded and followed by non-detections. The 11 wells where the detections occurred were sampled in the two-month periods immediately before and immediately after August 17, 2007. Seventeen samples were collected in the two-month period before August 17th. All of the results were between 20 µg/L and 1000 µg/L. Thirty samples were collected in the two-month period after August 17th. Twenty eight of the results were between 20 µg/L and 1000 µg/L, one result was less than 20 µg/L, and one result was more than 1000 µg/L.

Although there are problems with the uranium analyses performed by URI's laboratory, careful consideration of the data leads to the conclusion that most of the uranium detections are not false positives.

Garcia wells

The Garcia family used to drink water from two wells on their property, W-24 and W-25 (figure 5). These wells are about 60 m apart, and less than 300 m northwest of PA-3. Both of them are completed in the Goliad Aquifer (figure 8). Their depths are approximately 180 m and 240 m (Saenz 2012a). Well W-24 is now used only to water cattle and goats, and W-25 is no longer used (Saenz 2012a).

Water from wells W-24 and W-25 has been sampled since 1996, if not earlier; the records are unclear (figure 9). Before mining began at PA-3, the average concentration of uranium was 180 µg/L. The uranium was probably due to the presence of uranium ore in the Goliad Aquifer where the Garcia wells are completed.

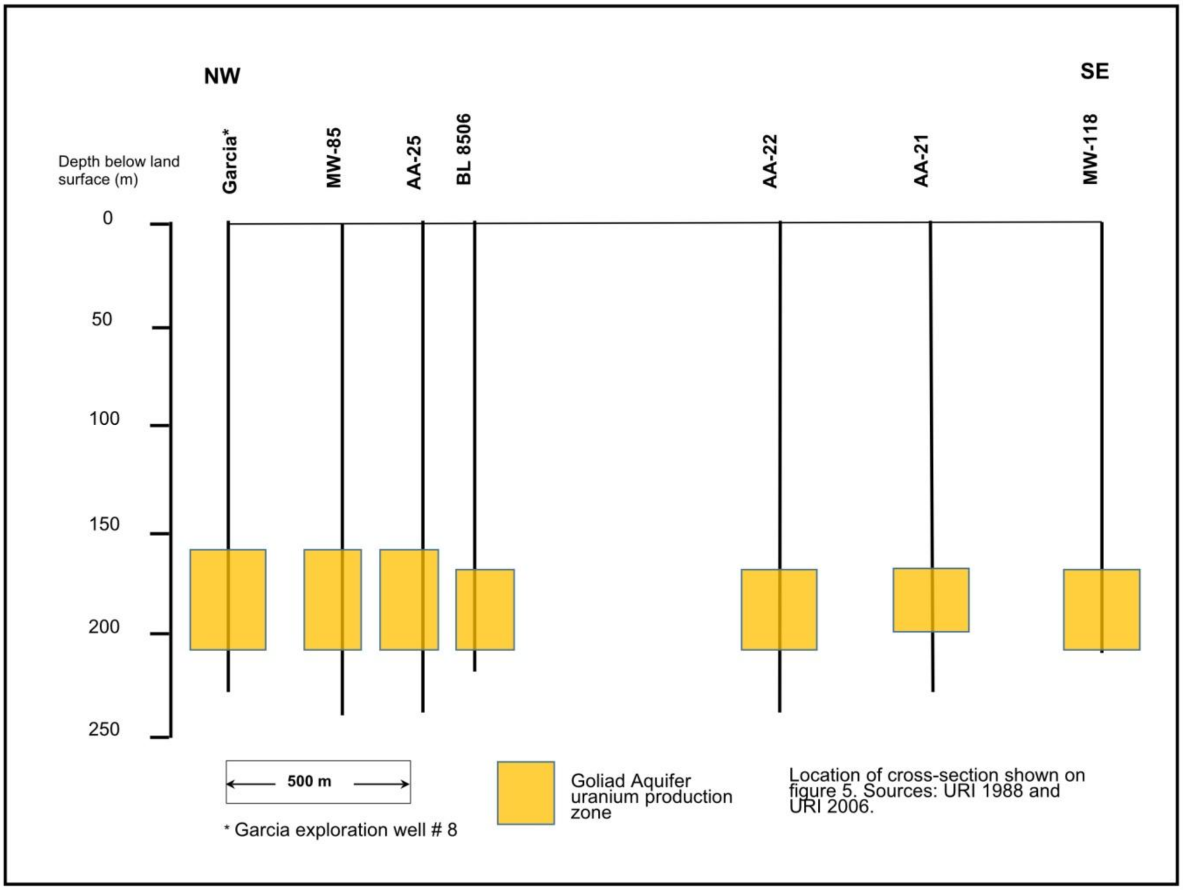

Figure 8. Cross section through PA-3 and Garcia property

Until late 2005, water from both Garcia wells was pumped to a single tank, and analyses were performed on samples from the tank. The only exception to this was in June 1998, when separate samples were collected from wells W-24 and W-25. The uranium concentrations were 152 µg/L and 167 µg/L, respectively. Since late 2005, W-24 has been sampled nine times and W-25 one time. The samples from W-24 had an average concentration of 670 µg/L, and the sample from W-25 had a concentration of 10.4 µg/L.

The cause of the low concentration in W-25 is unknown. W-25 no longer contains a pump. At the time it was sampled, W-25 had been unused for about two years and the sample may have been affected by deterioration of the well casing (e.g., occlusion of uranium by precipitating iron). The sample was collected by the author after purging three bore volumes. At the beginning of the purge, the water appeared to be black. When the sample was collected, the water was lightly tinted.

There are two possible causes of the increased uranium concentrations in W-24. First, concentrations in W-24 may have always been high, but were diluted in the tank by low concentrations from W-25. Second, they represent excursions from PA-3.

There are two problems with the first possibility. First, when W-24 and W-25 were individually sampled in 1998, the uranium concentrations were about equal. Second, the volume of water pumped into the tank by each well appears to have been about the same. Three horse-power pumps were installed in both wells, and when the storage tank was filled, both wells turned on and off at the same time. (Saenz 2012b). When the author sampled the wells in December, 2008, both wells produced water at a rate of about 35 L/min. An equal mixture of waters containing 10 µg/L and 670 µg/L uranium would contain 340 µg/L uranium. This is almost twice the average value measured in the tank between 1996 and 2005.

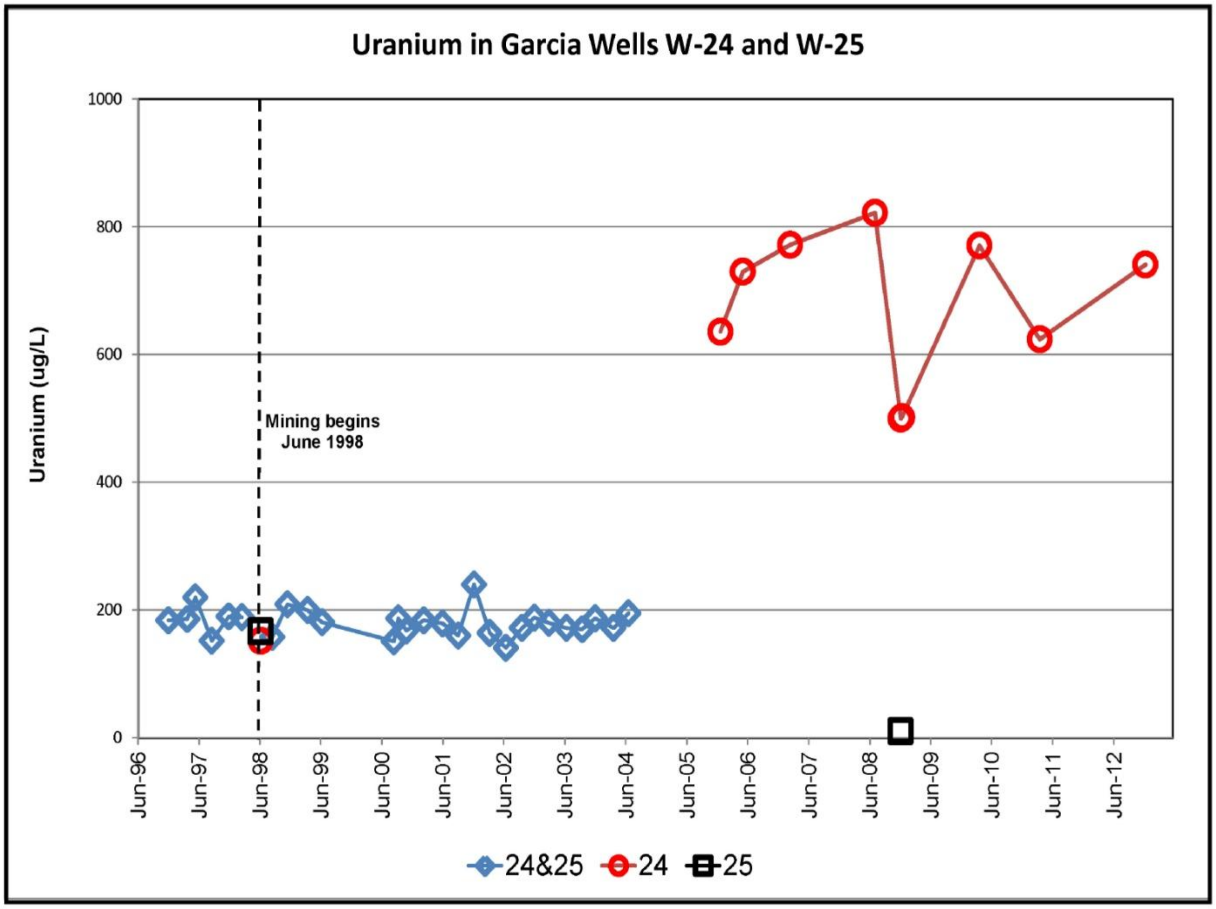

Figure 9. Uranium Concentrations in Garcia Wells

There is also a problem with the second possibility. The increased uranium concentrations in W-24 were first detected in late 2005, but excursions at PA-3 were not reported until 2007. However, unreported excursions, that is excursions where the uranium concentration did not reach the 1000 µg/L threshold, probably did occur. This possibility is supported by the following. First, the increased concentrations occurred after mining began at PA-3. Second, the general direction of groundwater flow from PA-3 is toward the Garcia wells, and flow may have been accelerated by pumping of the Garcia wells. Third, excursions have been detected in monitor wells less than 600 m from the Garcia wells (figure 5).

The available data indicate that the likely source of the increased uranium concentrations in the Garcia well is PA-3. To the author's knowledge, this is the first time that contaminants in an off-site domestic well have been linked to ISL uranium mining in the United States of America.

Conclusions

Although there are uncertainties associated with some of the available information, a conservative assessment leads to the following conclusions.

1) The injection of leaching fluids at PA-3 created a hydraulic gradient that caused mining solution to flow from injection wells, toward the monitor well ring.
2) The mining solution contained concentrations of uranium that were significantly higher than background concentrations.
3) Excursions occurred. That is, mining solution flowed beyond the monitor well ring surrounding PA-3.
4) The excursions reached the Garcia property. They caused uranium concentrations in well W-24 to increase from an average of less than 200 μg/L, to more than 600 μg/L.

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Note

Historical Observations of Droughts and Floods in Austin, Texas: An Interview with Dr. Jack Schneider

Interview by Brian Butler Hunt

Preface:
*Photographs can help us understand the gravity of devastating natural, and human-influenced, disasters. I showed an iconic drought photo at a talk I was giving at the La Querencia retirement community. After the talk the son of the man who took the photograph I had shown contacted me. I knew very little of the photograph and so I was eager to learn more. The result was a long discussion with Dr. Jack Schneider, a long-time resident of Austin, about water in Central Texas (**Figure 1).** Highlights of that discussion are provided below in an interview format.*

***Figure 2** is the photograph that initiated this interview—it's the photograph that Dr. Schneider's father took of a young man (his friend Emory Hughes) straddling the Colorado River during the drought of 1917--just upstream of where the Tom Miller Dam is today. There were no dams functioning at that time, so the diminished flows seen in the photo represent actual river flows. We can assume that without the dams, the 2009 and 2011 low flows would be equivalent or lower than what is shown in the picture. In addition, Dr. Schneider witnessed the 1935 flood as an 8-year old boy from the south bank of the river along Congress Avenue--similar to the view shown in **Figure 3.** The devastating floods of 1935 were again repeated in 1936, and then in 1938 until the Highland Lake system of dams were built in the early 1940s.*

***Figure 1.** Dr. Schneider holds the photograph his father took of Mr. Emory Hughes (age 16) in 1917 as he straddles the Colorado River. Learning more about this photograph is what initied the interview.The interview occurred on September 30, 2013 at the La Querencia, west of Austin. The transcripts and recordings were submitted to the Austin History Center.*

Figure 2. *Photograph of Mr. Emory Hughes (age 16) straddles the Colorado River in Austin Texas in 1917. Mr. Hughes is wearing his St. Edwards ROTC uniform. The photograph was taken by Mr. Schneider about where Enfield Road meets the river. Photography courtesy of the Schneider Family and the Austin History Center.*

Figure 3. *Photograph looking north along Congress Avenue during the flood of June, 1935. Photograph courtesy of the Austin History Center PICA 22060. The two-story house in the foreground still stands today as an engineering office (907 S Congress Ave). The two-story structure in the middle of the picture surrounded by flood waters, was called South Austin or Ward Body Shop at the time of the flood. Today, the building (220 S Congress Ave) contains various commercial tenants.*

Interview:

Brian Hunt (BH)- I guess if you don't mind, starting by talking a bit about yourself.

Dr. John (Jack) Schneider (JS)- I am known as Jack. I laughingly tell my patients when I introduce myself that John signs the checks and Jack is your buddy. I was born May 18, 1927. We went through the depression times and my daddy had a grocery store. You may know the history of the old Schneider store and all that business. The Schneider family was four brothers and when my grandmother and granddaddy had died and they were selling the estate and my granddads store, they talked my daddy into running the store and handling the properties. All of my knowledge is from my dad. During the depression I grew up in Travis Heights and we had a store out there in addition to the old Schneider store at Second and Guadalupe.

BH- Was your father a photographer? *(referring to figure 2)*

JS- No, no. When he grew up he went to St. Edwards High School, up on the Hill. So the picture that you see was when he was in the ROTC at St. Eds. That's right. (Referencing photograph of soldier straddling river). We have always been told, and I have no reason to doubt it or question it. We had the original picture of that, Ellie did. That was about 1917, and so dad would have been 16 or 17 years old. That picture is of Mr. Emory Hughes. Mr. Hughes, one of the Hughes family, had a huge ranch at the Marshall Ford/Mansfield Dam area. When school was out on weekends or during the summers they would hike up the dry river bed, the (Austin) dam was out at that time and hadn't been rebuilt, and there was drought. What he's straddling there is the Colorado River, and you can see there is not much water coming down there. And that is what I'm concerned about today. Is that there is such inadequate water coming into Lake Travis and Buchanan today. There is not enough water there to take care of the City of Austin and all these people that they are bringing in here out of California and everyplace else. And incidentally, these people don't understand our local environment and the encroachment of the Chihuahuan desert coming this way. People have no concept of that, and I've found that since I lived here (Querencia). I have the same picture here; we gave the original to Mrs. Hart at the Austin History Center. Ellie took it down there and said that's where we need to put the picture. So that's the dry river bed and that's roughly where Enfield Road or Windsor Road area comes down to the river. I tell people it was near the Garcia or Morrison estate.

BH- It's a fantastic photograph, so your dad when he was 16 must have had a camera.

JS- Yes, he must have had one of those old box cameras.

BH- Yeah, it illustrates the concepts true then and true today. It is a wonderful picture that I was glad to hear you knew something about it.

JS- When my grandfather died--a little more of my background--his sons were helping my grandmother settle the estate. They owned a general store and they found a lot of IOUs and notes from people. He would grubstake people who didn't have cash. One of the notes was secured by a cotton gin in Elgin or Manor; I don't recall which one, or a pecan grove on the Colorado River on Thurman Bend. Have you ever heard of Calcasieu Point?

Ok, that is Thurman Bend. If you go there, Mr. McCombs has a big development there now. The brothers took that Pecan Grove as security on the note. The man couldn't pay it. They were trying to help my grandmother. Instead of the cotton gin. They were smart, as cotton went out about that time. As it turned out though the value of the pecan grove went in 1935. The pictures I have here of that terrible flood. Ok? It wiped out 75% of the pecan trees. Then, I believe it was in 1937 there was another flood that took almost the rest of those beautiful pecan trees. I remember walking down in those trees; it was like walking beneath the big ones at Barton Springs that was the way that whole mile of river front used to be. The family used to camp down there and I remember so well I swam in the Colorado River. You could walk across it in on the rocks; it was a narrow spot in the river. That was the Thurman Bend road that forded the river.

Floods of 1935. Do you have those pictures? I lived in Travis Heights and my dad had a store at 1200 South Congress near the Deaf School. I stood on the Colorado River on the street. This photo is before it came up really high.

BH- Well, this is (a photo of a flood in) 1936.

JS-I don't know whether that is true or not. Something is not right about that (referencing the picture of the Colorado River flooding along Congress, dated 1936). That may not be marked right. This is what I remember (looking at aerial picture of flood along Colorado River and Congress). Travis Heights incidentally, that's a mistake people make, does not come down to Congress. It doesn't start for about ½ mile to the east (of Congress).

I stood right here, this is the deaf school, I stood right here as a little boy and watched the dirty roiling water churning carrying trees and houses. There used to be a motel or tourist court right here. Mr. Odam (?) Crockett owned them, I believe, and the flood took all of them out. The only thing that stood up was Ward Body Works. That's the concrete building that still stands today. This is the Congress Avenue Bridge. It came right to the bottom of that. This is my granddaddy's store, somewhere here; it was about 2 ft or so up into the store (pointing to along 1st street).

The Dams incidentally were not built for water supply for Austin, but for flood control. Everybody says we should watch the water level in the lakes, and that is true, and we should be glad to have them. I stood right along here. I was 8 years old. I bet my folks didn't let me get too close.

BH- After the flood you mentioned the pipes were severed to South Austin.

JS- The Norwood's had a 2 acre estate. That is today where people walk their dogs (Dog Park at Riverside and IH-35). They had a 2 acre nice estate, pecan trees and things like that. My mother out of High School was Mr. Norwood's secretary. We would go down there and have free use of their pool. But during the flood, since there was no water, they filled their swimming pool up (with their flowing artesian well) and the fire trucks in south Austin, this all according to my memory, pumped water from the pool into the pipes so folks could use their utilities. It was not potable. There was an artesian well there. I've told you about it. *(BH note: it is well state Well No. 58-51-103, 1600 ft deep, producing from the Middle Trinity Aquifer, TDS = 1238 mg/L*).

BH- You also mentioned Stacey Pool and St. Edwards had artesian wells.

JS- That's Travis Heights, which ends at the (Blunn) Creek. There's a well at the State Capitol building. My dad swam at St. Edwards. My dad learned to swim in the river where the railroad bridge is.

BH- My grandfather (Mike Butler) told me that the railroad bridge was the only bridge to survive the various floods.

JS-Judge John Brady is year older than I am; he lives out somewhere near Brodie Lane. John's a fine man. His daddy was a doctor, lived in Travis Heights, and used to walk the railroad bridge morning and nights to go to and from the office.

BH- Did you go to Barton Springs very often?

JS- I lived down there in the summer time. Everyone did. You paid to get in on the north side, and the south side you sneaked in. You road your bike, parked, and ran down the hill and spread a big blanket. In the winter time you'd go swimming and 2-3 guys would hold a blanket up and you'd change into your bathing suit—the cold—then you'd run down the hill and jump in. It's the same temperature year round. I haven't been back since college.

--Gap in the recordings—

> *I recall Dr. Schneider discussed a visit he and his father would take out to Hamilton Pool to visit the Reimers. He mentioned that floods or high-water crossings of the creeks in his father's car was a problem. The fan would hit the water and splash the water into the distributor cap or other parts and kill the engine. He recalled his father loosening and removing the fan belt as the crossed the creek and then reattaching it on the other side of the creek.*

The discussion ended on more recent water policy, and family history etc.